



# THE DOE ATMOSPHERIC SCIENCE PROGRAM

*Chemical and Microphysical Processes Affecting Atmospheric Aerosols  
And their Influences on Atmospheric Radiation and Climate*

Stephen E. Schwartz, BNL  
ASP Chief Scientist

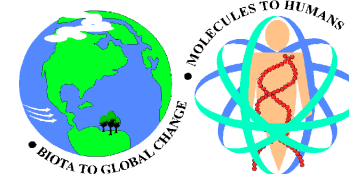
ACCESS - Atmospheric Chemistry Colloquium for Emerging Senior Scientists  
Yellowstone National Park

September 2-4, 2005

U.S. Department of Energy



*DOE's  
Climate Change Research Division*



Office of Science

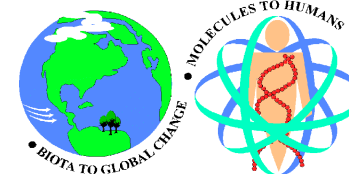


**Jerry Elwood, Director**

**[http://www.sc.doe.gov/ober/CCRD\\_top.html](http://www.sc.doe.gov/ober/CCRD_top.html)**



## *DOE's contribution to the US Climate Change Science Program*



- **Improve understanding of factors affecting the Earth's radiant-energy balance;**
- **Predict accurately any global and regional climate change induced by increasing atmospheric concentrations of aerosols and greenhouse gases;**
- **Quantify sources and sinks of energy-related greenhouse gases, especially carbon dioxide; and**
- **Improve the scientific basis for assessing both the potential consequences of climatic changes, including the potential ecological, social, and economic implications of human-induced climatic changes caused by increases in greenhouse gases in the atmosphere and the benefits and costs of alternative response options.**



## High Priority Questions for DOE Climate Programs

- What is the likely effect of increasing concentration of greenhouse gases and aerosols on the future climate? *Climate Change Prediction Program. PM, Bamzai. Chief Scientist, Dave Bader.*
- What is the effect of clouds on climate? *Atmospheric Radiation Measurement (ARM) Program. PM, Ferrell. Chief Scientist, Warren Wiscombe.*
- How much of the carbon dioxide emitted into the atmosphere from human activities is taken up by terrestrial ecosystems and the ocean? *Terrestrial and Ocean Carbon Cycle Research. PM, Amthor.*

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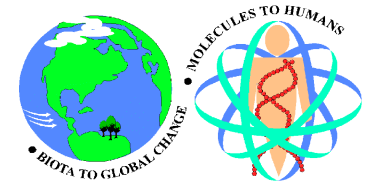


## High Priority Questions for DOE Climate Programs (Cont'd)

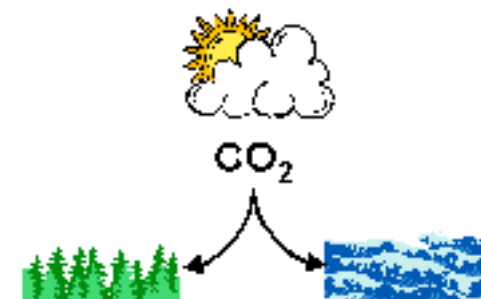
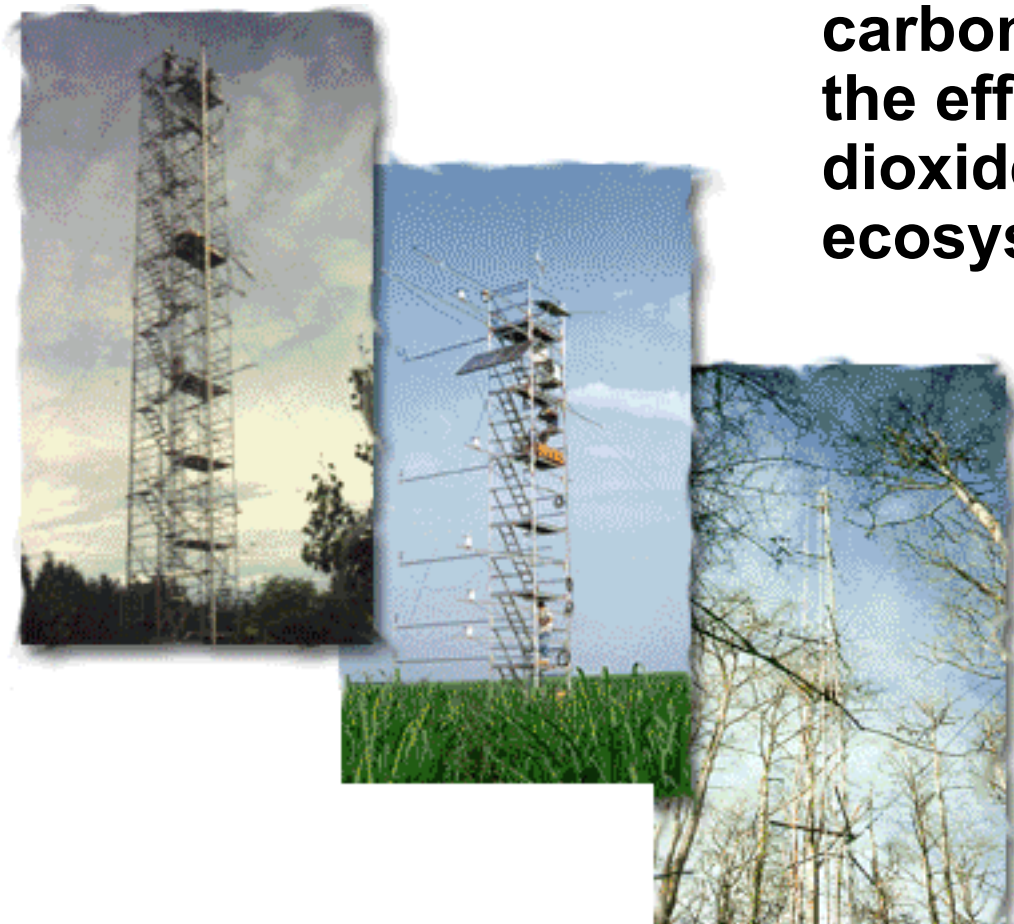
- How do other energy-related emissions besides carbon dioxide affect the Earth's radiation balance and air quality? *Atmospheric Science Program.* PM, Petty. Chief Scientist, Steve Schwartz.
- How can carbon sequestration in terrestrial and ocean systems be enhanced and what are the potential environmental consequences of purposely enhancing it? *Ocean and Terrestrial Carbon Sequestration Research Programs.* PMs, Amthor, Dahlman.
- What are the effects of atmospheric and climate changes due to energy-related emissions on ecological systems and resources? *Ecological Processes Program.* PM, Amthor.
- What are the economic costs and benefits of climate change and of options for mitigating the change? *Integrated Assessment Program.* PM, Houghton.



## Carbon and Ecosystem Research



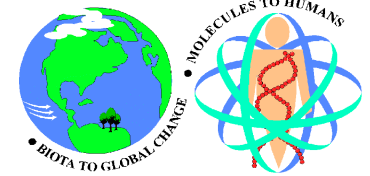
- Quantify the North American carbon cycle and understand the effects of elevated carbon dioxide on terrestrial ecosystems.



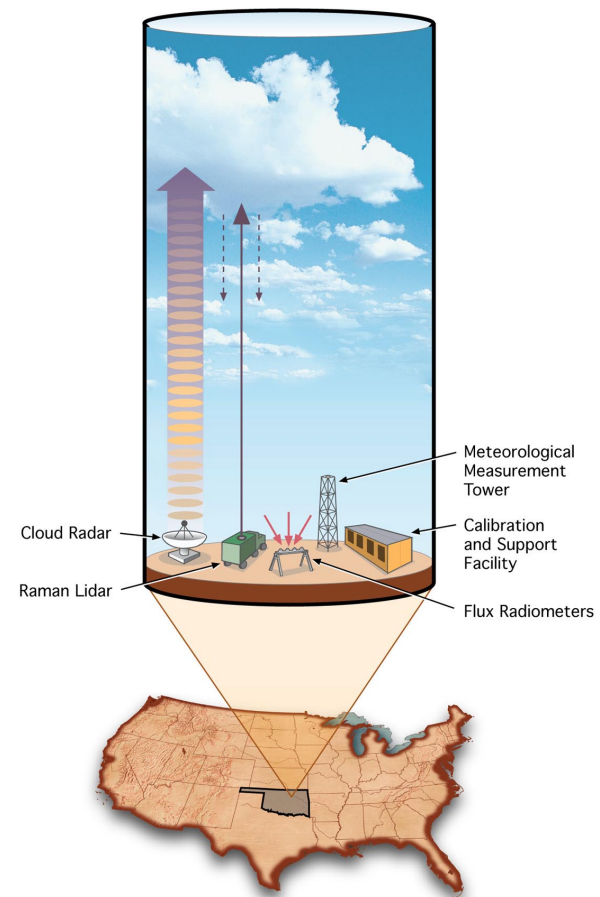




# Atmospheric Radiation Measurement (ARM) Program

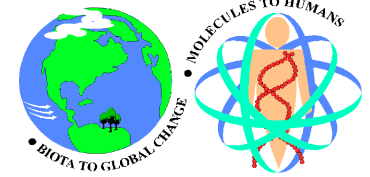


- Understand the role of clouds and solar radiation for use in climate models.
- Understand the water cycle to better predict precipitation patterns.

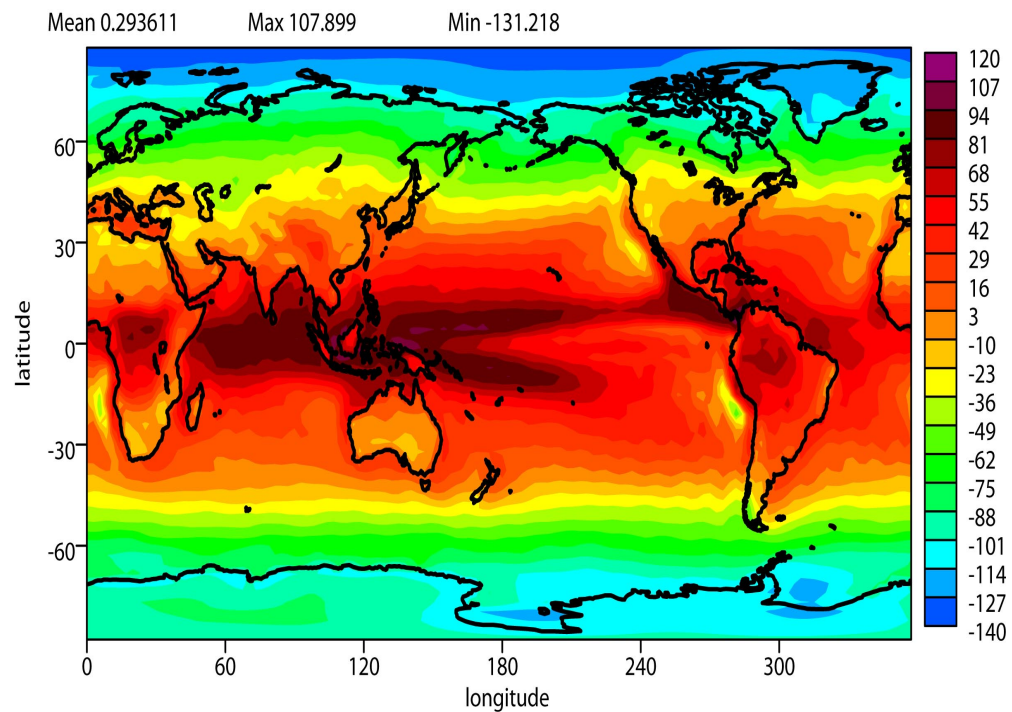




## Climate Modeling



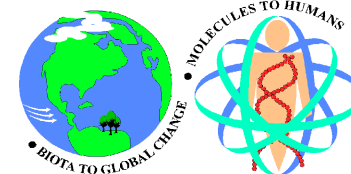
- Improve regional and global scale simulations and predictions of climate.



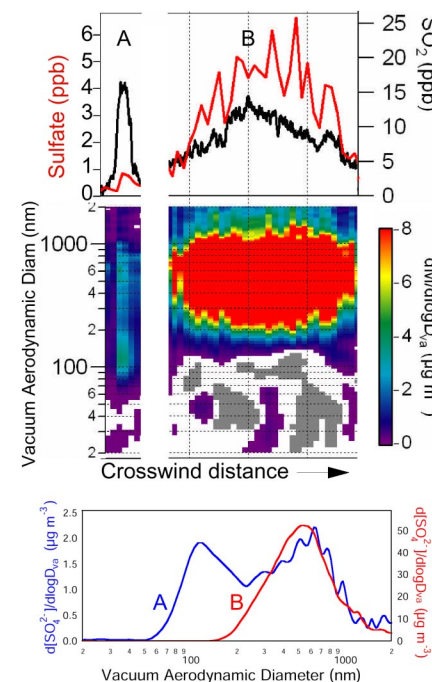




# Atmospheric Science Program (ASP)

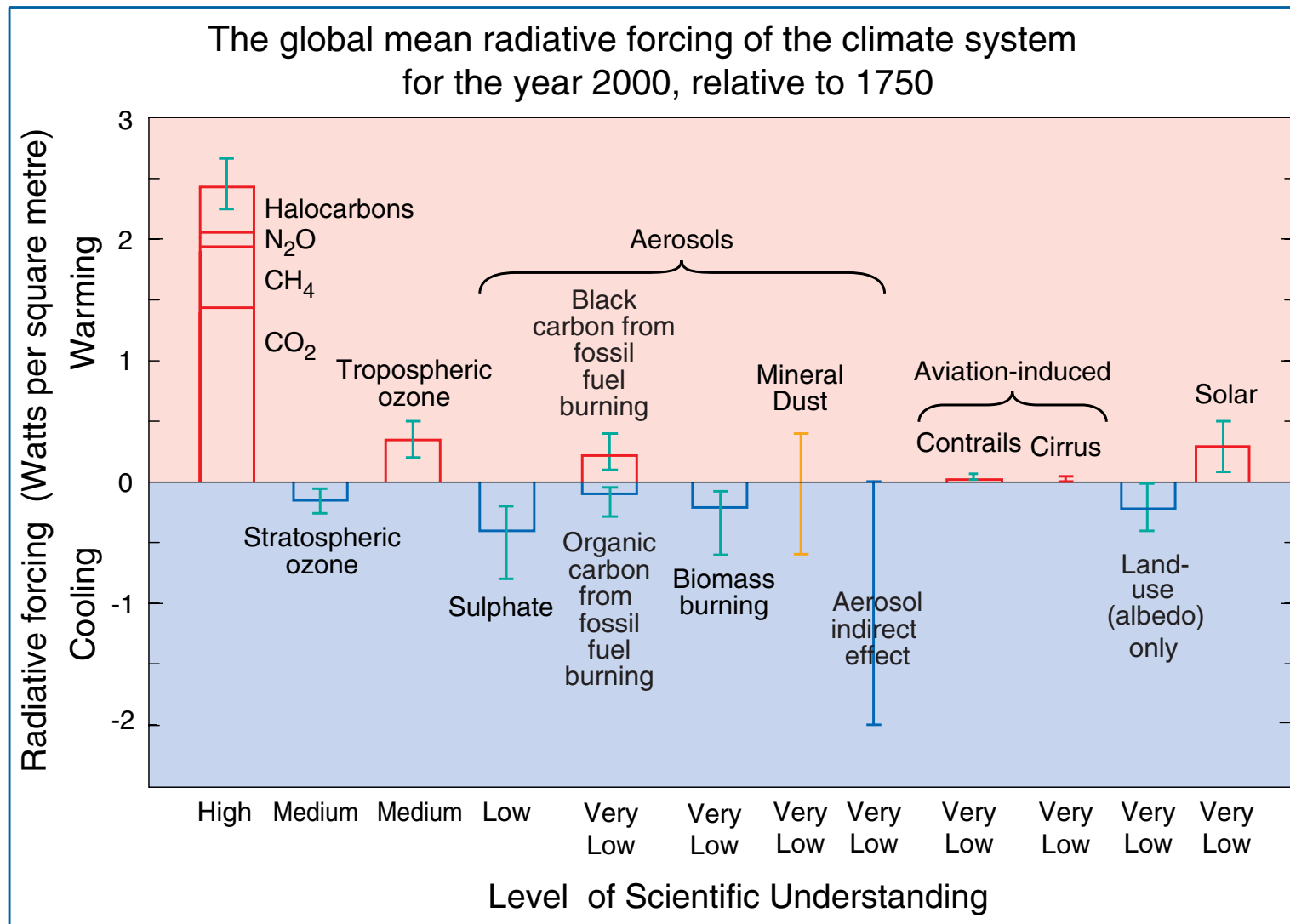


- Develop understanding of aerosol radiative forcing of climate--aerosol formation and evolution and aerosol properties that affect direct and indirect influences on climate and climate change.
- Represent this understanding in models that can be used to identify and quantify these influences on regional to global scales.

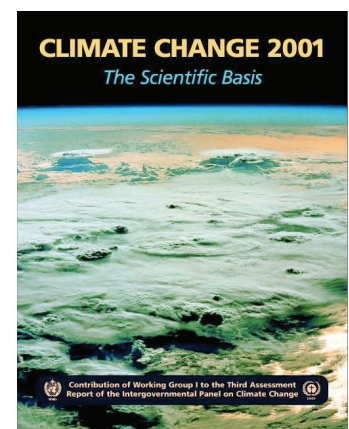


# RADIATIVE FORCING OVER THE INDUSTRIAL PERIOD

## IPCC (2001)

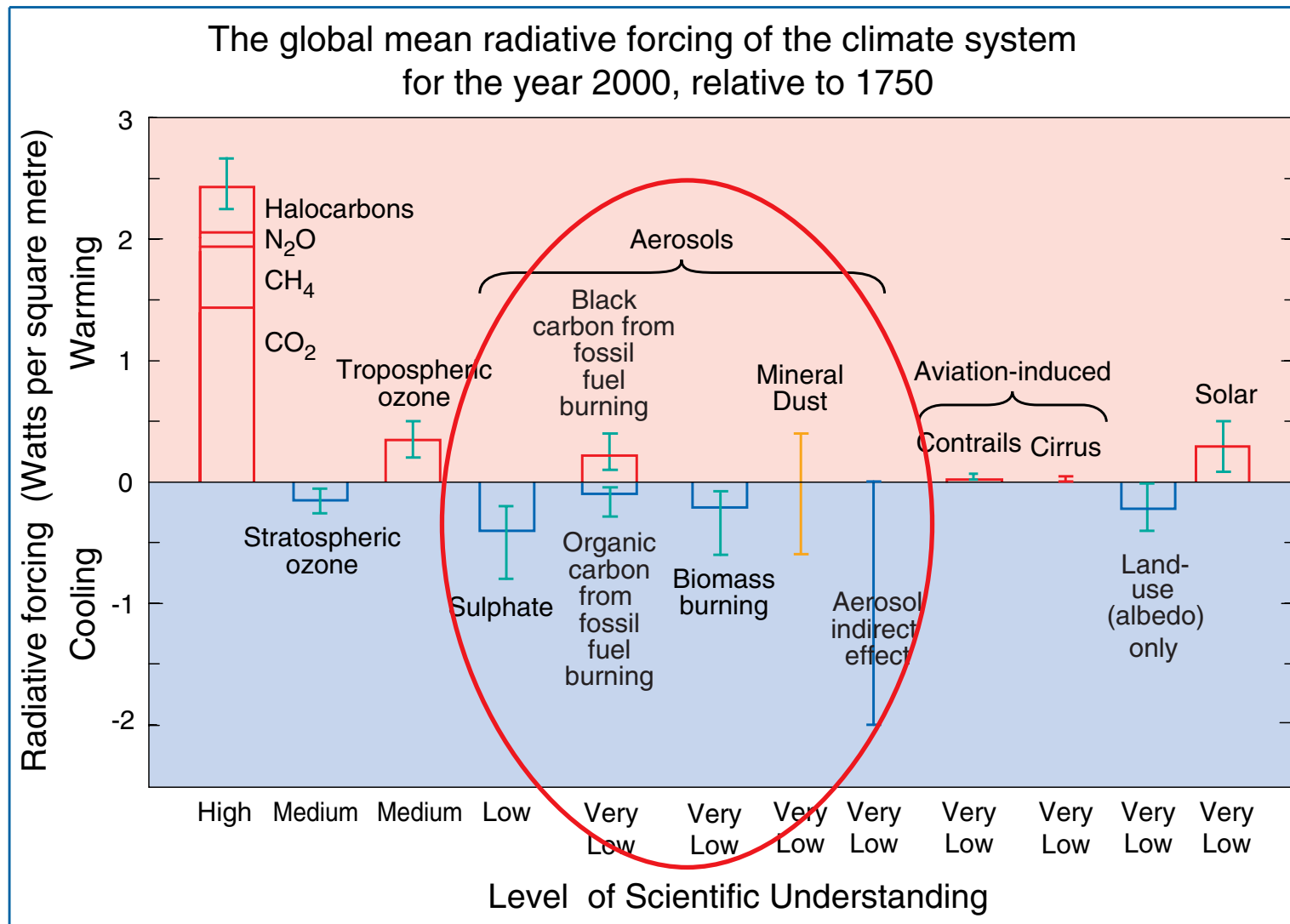


**Summary for Policymakers** A Report of Working Group I of the Intergovernmental Panel on Climate Change



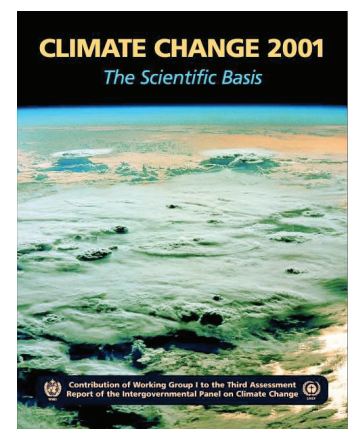
# RADIATIVE FORCING OVER THE INDUSTRIAL PERIOD

## IPCC (2001)



Summary for Policymakers

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# WHY SO LARGE UNCERTAINTY IN AEROSOL FORCING?

- *Uncertainties in knowledge of atmospheric composition*

*Mass loading and chemical and microphysical properties and cloud nucleating properties of anthropogenic aerosols, and geographical distribution.*

*At present and as a function of secular time.*

- *Uncertainties in knowledge of atmospheric physics of aerosols*

*Relating direct radiative forcing and cloud modification by aerosols to their loading and their chemical and microphysical properties.*

# AEROSOL INFORMATION REQUIRED TO DETERMINE DIRECT FORCING

*Time-dependent 3-D map* of size-dependent particle concentration, composition, and morphology.

*Needed* for computation of optical properties, cloud-nucleating properties, and radiative and hydrological influences.

*This can be obtained only by chemical transport modeling of aerosols ...*

Based on *understanding* of the controlling processes.

*Evaluated* by comparison with observations.

*Concentrations*

*Composition and size-dependent composition*

*Microphysical and optical properties*

*Rates*



# REPRESENTING AEROSOL PROCESSES IN CTMs

*Sources* of primary particles and precursor gases

*3-D transport* as controlled by governing meteorology

*Gas to particle conversion* (clear air and cloud)

- New particle formation

- Accretion onto existing particles

*Particle size evolution* (clear air and cloud)

Particle *morphology* and intra-particle structure

*Removal* of particles and precursor gases, controlled by meteorology

Aerosol properties as *bivariate functions of particle size and composition*

Aerosol optical properties (extinction coefficient, single scatter albedo, asymmetry parameter) as integrals over single particle properties (Mie)

All as a function of *3-D location and secular time*



## Atmospheric Science Program (ASP) Program Deliverables



*Models and parameterizations* suitable for representing aerosol properties and processes required to compute aerosol radiative forcing of climate in large-scale climate models, together with an assessment of their accuracy and limitations. . .

- Relating *aerosol light scattering and absorption*, including dependence on relative humidity and other controlling variables, to aerosol chemical and microphysical properties.
- Relating *cloud microphysical properties* and dependence on controlling variables, to concentration, and chemical and microphysical properties of pre-cloud aerosol.
- Relating the *evolution of aerosol composition and microphysical properties*, and optical and cloud nucleating properties, to concentrations of precursor gases, properties of the pre-existing aerosol, cloud processing, and other controlling variables.



# Atmospheric Science Program (ASP) Science Deliverables



- 1. Field measurements
- 2. Laboratory studies
- 3. Instrument development
- 4. Models, modules, and parameterizations
- 5. Dissemination of research results

## ***DOE Research Aircraft Facility***



**Grumman Gulfstream 159 (G-1) twin turboprop aircraft**

# DOE RESEARCH AIRCRAFT FACILITY INTERIOR VIEWS



View Forward



View Aft

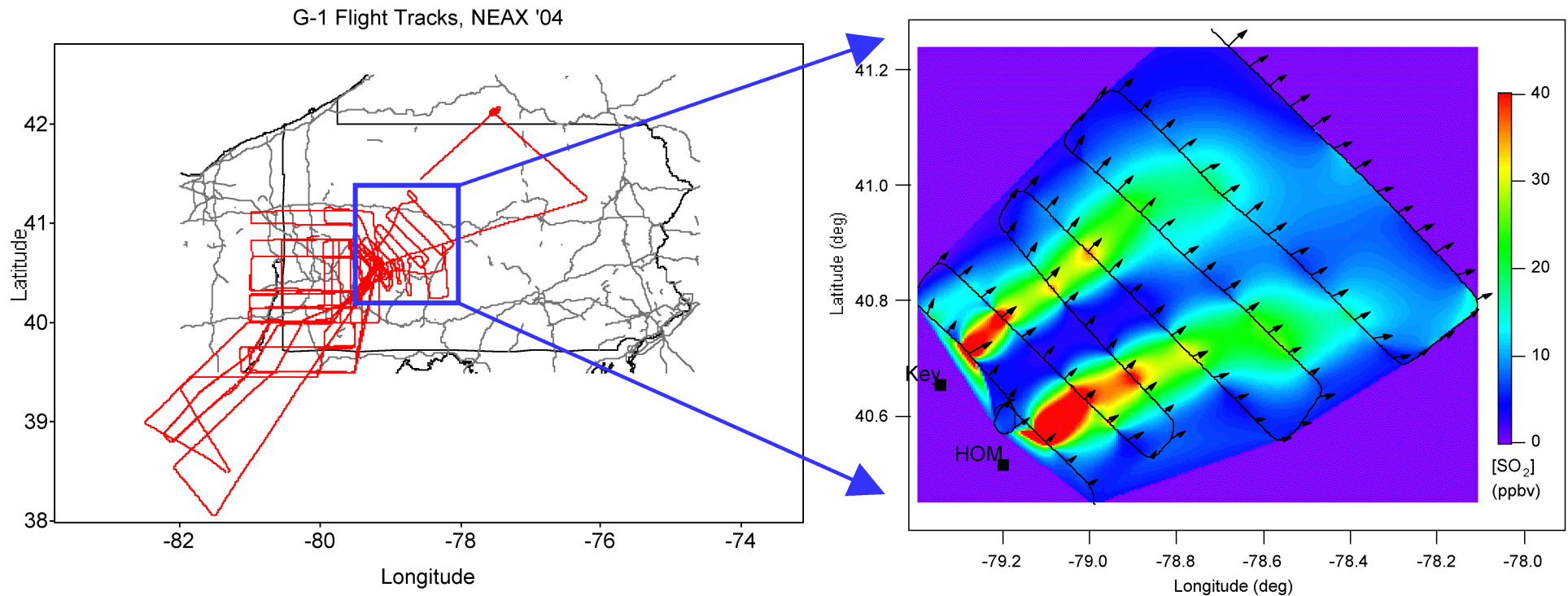


# DOE RESEARCH AIRCRAFT FACILITY



Scientists and flight crew participating in 2005 MArine Stratus Experiment (MASE) off California coast

# RECONSTRUCTION OF ATMOSPHERIC CONCENTRATION FIELDS

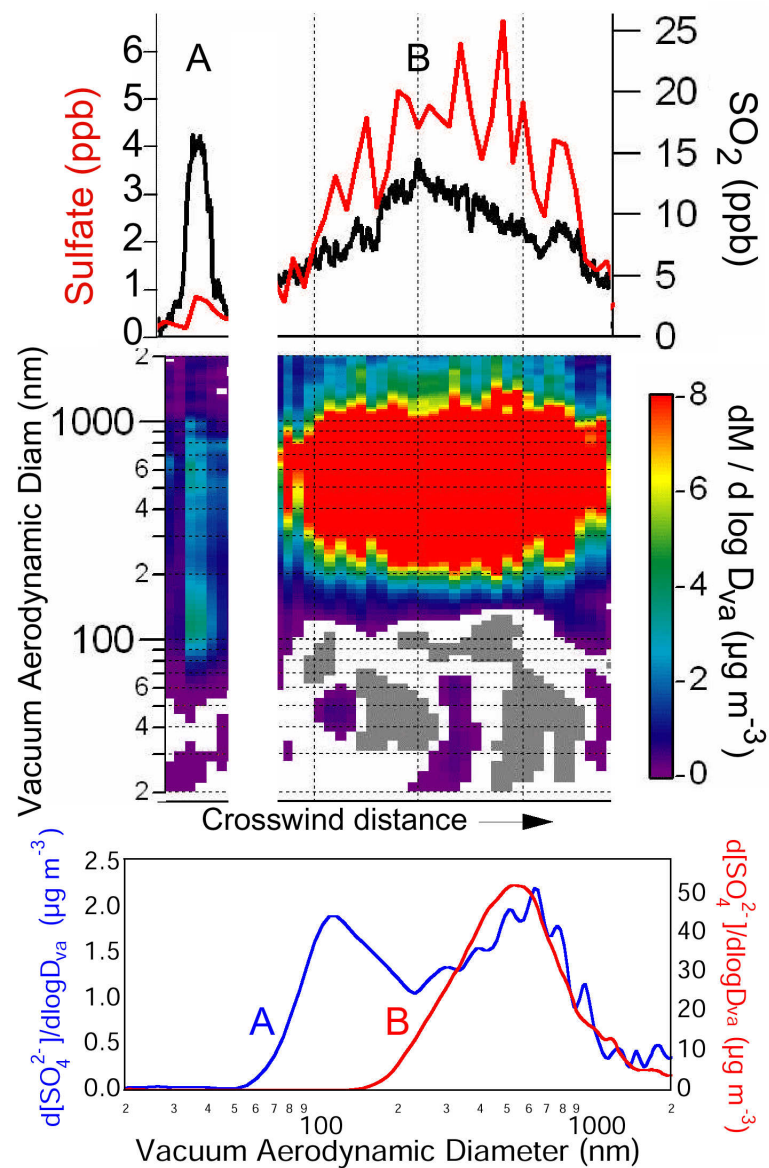


Two-dimensional reconstruction of SO<sub>2</sub> mixing ratio in plumes downwind of Keystone and Homer power plants from aircraft transects

# AIRCRAFT MEASUREMENTS OF SO<sub>2</sub> AND SULFATE

## Massachusetts Bay, July 22, 2002

A: 400 m MSL; B, 1200 m MSL



John Jayne, Aerodyne, Inc.

U.S. Department of Energy

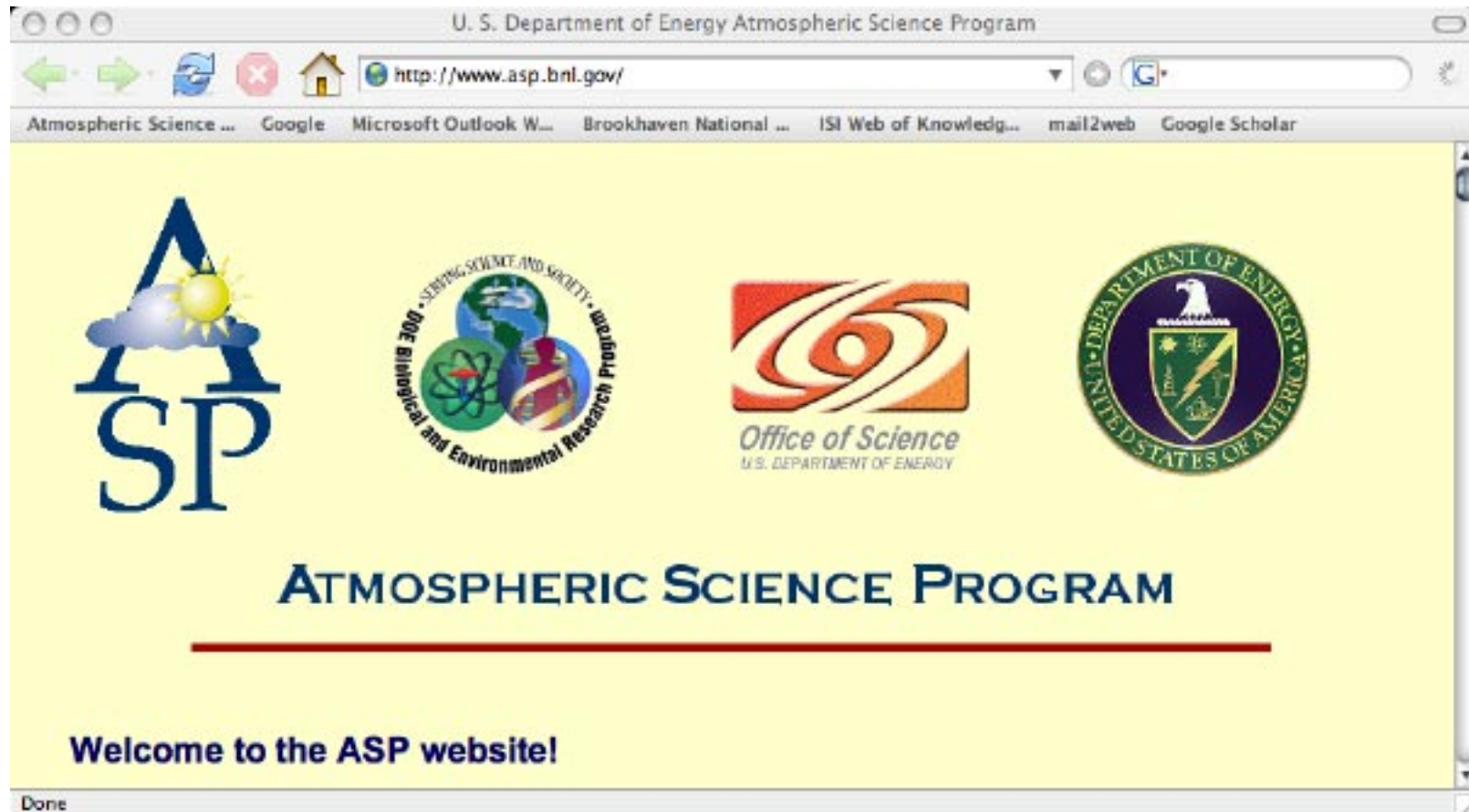


Office of Science

# Atmospheric Science Program (ASP)



For further information please visit  
[www.asp.bnl.gov](http://www.asp.bnl.gov)







# Atmospheric Science Program (ASP)



U. S. Department of Energy Atmospheric Science Program

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